



R.C.A. INSTITUTES.

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Technical Lesson 12

THE MOTOR-GENERATOR

The motor and the generator which you have just studied becomes a motor-generator when coupled together and mounted on a common base. There is no difference in the fundamental design of either the motor or generator. The shaft of the motor is mechanically coupled to the generator shaft which makes the two machines one unit - a motor-generator set. This combination is extensively used in radio practice. On ship-board the current is D.C. and in our radio work it is necessary to have current of an alternating nature available. Therefore we use a motor which operates on direct current with the shaft of the motor directly connected to the shaft of an alternating current generator and both machines being mounted on a common iron base. Figure 1 shows a modern motor generator set used for radio operation. The motor is at the left of the base and the generator on the right. This method of coupling the two machines together is clearly shown, together with the housing for the bearings used to support the shafts of the motor and generator. In this case the motor and generator have independent bearings.

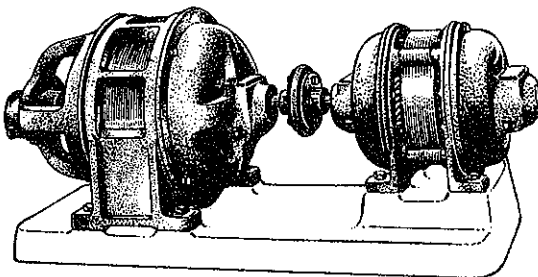


Figure 1

In some machines the coupling plate used is a specially prepared disc of flexible material which will withstand the twisting strain of the motor shaft turning the generator armature. This allows for small irregularities in the alignment of the shafts. Where a solid mechanical connection is made the tightening of the bolts in the coupling device might easily throw the shaft out of alignment causing it to bind on one or more of the bearings. In Figure 2 is illustrated the general outline of the motor-generator, all bearings and bearing housings being omitted for the sake of clearness. Let us run over this assembly and see what we have by comparing the numbers in the list given below.

1. The switch controlling the direct current supply.
2. The leads connecting the main line current supply with the motor armature.
3. The direct current motor.
4. The armature of the motor.
5. The commutator of the motor.
6. The motor brushes.
7. The motor shaft.
8. The leads running from brushes supplying current to the motor field windings.
9. The motor field coils.

It now becomes necessary to divide the motor-generator equipment into three separate classes according to the winding employed in the field coils.

The first type, shown in Figure 2, is a shunt wound motor coupled directly to the alternator; second, the same type of motor coupled to an A.C. generator having a compound wound field and, third, the motor field winding is of the differential compound wound type coupled to a simple A.C. generator. Let us consider these three divisions by studying the simple schematic drawings of Figures 3, 4 and 5.

Before we go further, if you have not already become familiar with the electrical symbols, place the sheet bearing these symbols before you as you study the drawings.

Figure 3 is the diagram of a simple shunt wound motor-generator set and has the same field and generator connections as shown in Figure 2. The parts are all clearly labeled. The regulating action, or automatic control, due to counter electromotive force, is the same as in the shunt motor you studied. In addition to this you will notice two regulating field current rheostats - one in the motor field circuit and one in the generator field circuit. We will explain the operation of these two rheostats.

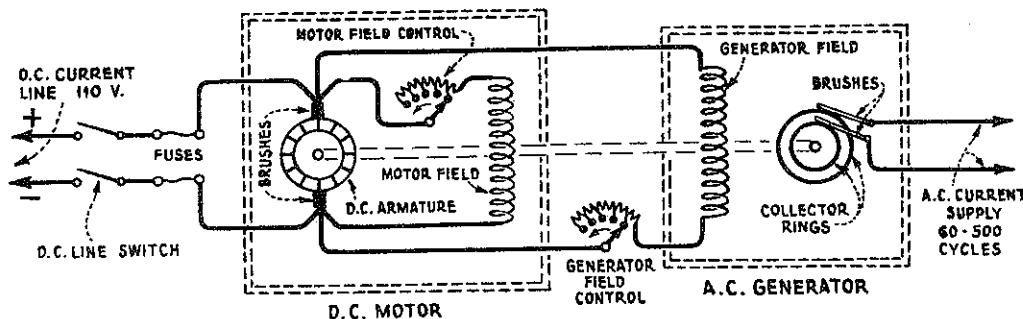


Figure 3

Beginning first with the motor field, if we turn the rheostat to the left as indicated by the arrow and more resistance is added to the field circuit this will reduce the current flowing in the motor field windings and thus weaken the magnetic field allowing the motor to speed up, which also increases the generator speed. It is very evident that the frequency output of the generator will be increased because its frequency partly depends upon its speed. By reversing this procedure, i.e., decreasing the motor field resistance by turning the rheostat arm to the right, the opposite effect is produced, that of reducing the frequency of the generator.

Now go through the same procedure with the generator field rheostat; turn it to the left as shown by the arrow thereby cutting in more resistance and, naturally, a decrease in current in the generator field results.

When resistance is increased in the field windings of a generator it weakens the magnetic field and this, in turn, reduces the generator output voltage. By turning the rheostat in the direction of the arrow less resistance is included in the field circuit, consequently more current flows into the field coils and a greater magnetic field results, giving the armature more lines of force to cut, hence a greater electromotive force, or voltage is produced.

Do not forget the results obtained when introducing resistance in a

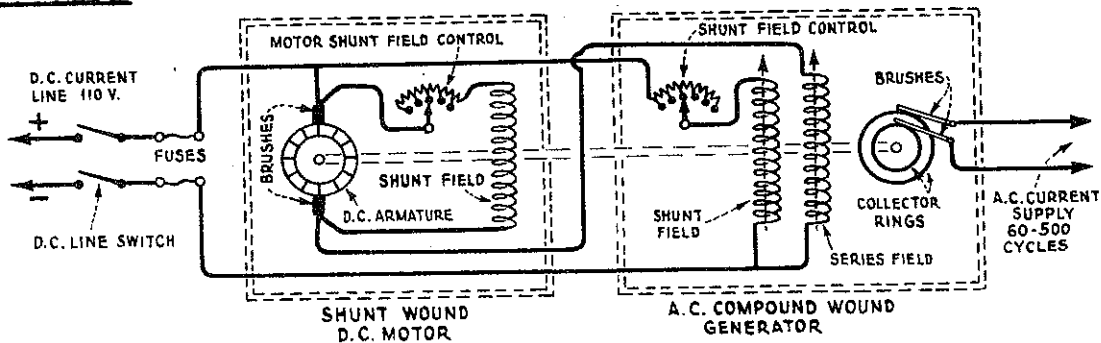


Figure 4

generator field winding and in a motor field. Be sure that you fully comprehend the two actions and do not confuse them.

In Figure 4 we have a shunt wound motor and compound wound generator; the motor and generator shunt fields have adjustable rheostats connected in their circuits enabling the speed of the motor to be regulated and the voltage of the generator to be controlled. When the desired speed of the motor is secured and the proper voltage output of the generator is obtained, these rheostats are left in that position.

The shunt and series field windings of the generator are connected in such manner that the field of the series winding and that of the shunt

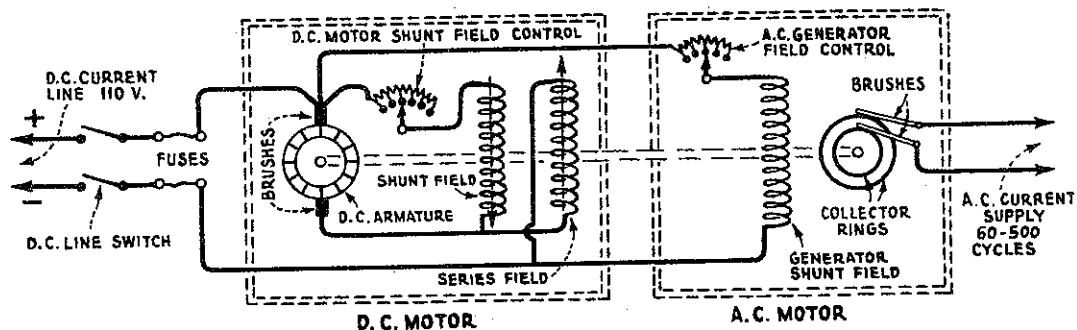


Figure 5

winding are in the same direction, i.e., of the same polarity. The motor-generator is subject to sudden loads when the telegraph key is closed and when this happens there is a tendency toward a decrease in speed; as this takes place there will be an increase of current flow through the series windings, because the series windings are in series

with the armature of the motor. This increased current flow through the series winding strengthens the field of the generator at once and it tends to restore the voltage to normal. Thus, in this type of motor-generator the speed of the motor and voltage output of the generator is maintained fairly constant under sudden variations of the loads.

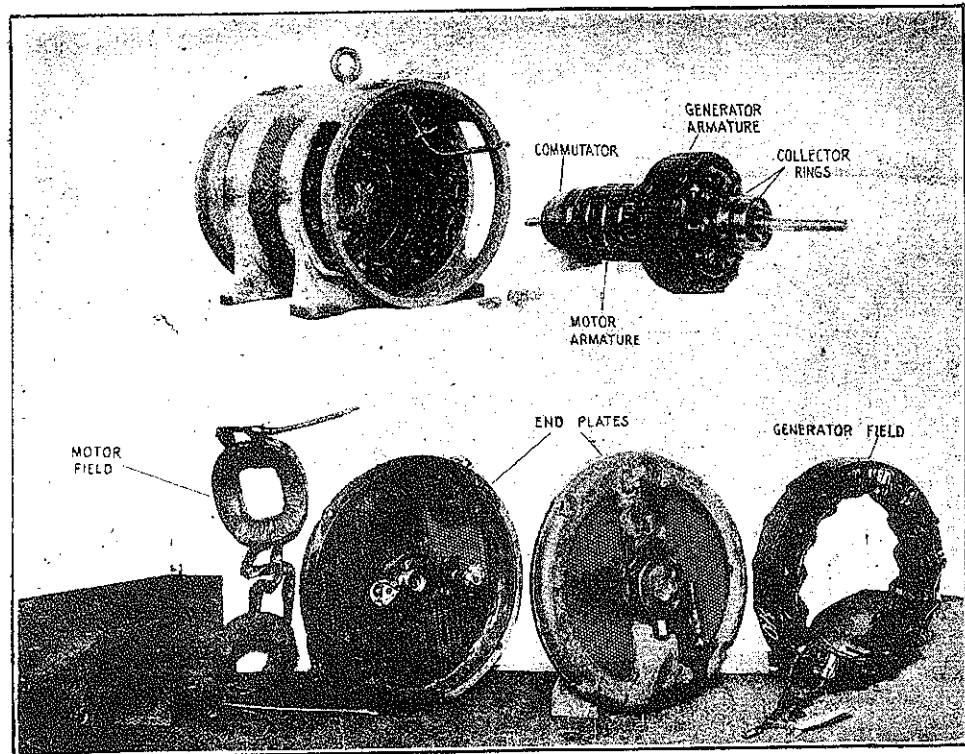


Figure 6

Now let us look at Figure 5. The motor in this case is differentially compound wound or, in other words, the shunt field is wound in one direction while the series field is oppositely wound, and when current flows through these two windings the field of one will oppose the field set up by the other. Suppose we analyze the effect of having the field of the series windings oppose the field of the shunt windings of this motor.

From the work you have covered you learned that when the field of a motor was weakened its speed increased. When a load is thrown on the generator in Figure 5 the speed of the motor is reduced thereby decreasing the counter E.M.F. As the shunt field is connected across the line it tends to remain normal in strength, and would tend to further reduce the speed. However, as the series field is connected in series with the armature it takes more current from the line and is thereby strengthened and, being wound opposite to the shunt winding, its field opposes, or tends to neutralize, the field of the shunt winding, further weakening the motor field as a whole. This weakened field allows the motor to gain speed at once, building up the counter E.M.F. which automatically restores the motor to its normal speed.

Motor generators employed with radio transmitters are rated in kilowatts. On shipboard you will find 1/4 KW, 1/2 KW, 1 KW and 2 KW machines for spark transmission. The frequency in cycles of any A.C. generator can be found as follows, using for example, the two kilowatt set of the Crocker Wheeler type shown in Figure 6. First we must know the number of pairs of poles and the speed of the armature in revolutions per second. This particular type of generator has 30 field poles and revolves at 2000 revolutions per minute.

Let F = frequency.
 P = number of pairs of poles.
 N = the speed in revolutions per minute.

Then " F " = $P \times \frac{N}{60}$ or $F = 15 \times \frac{2000 \text{ R.P.M.}}{60 \text{ seconds.}}$ $F = 15 \times 33.3 = 499.5$
 We would, then, say that the frequency is 500 cycles.

The motor will require about 29 amperes under a pressure of 110 volts to drive the generator armature which delivers voltages varying from 120 to 380 volts and a current output of about 20.8 amperes. From the above we can also determine the electrical horse power of the motor by multiplying 29 amperes times 110 volts and divide this by 746 watts, or one electrical horse power. Electrical H.P. =

$$\frac{29 \times 110}{746} = \frac{3190}{746} = 3190 \div 746 = 4.27 \text{ horse power.}$$

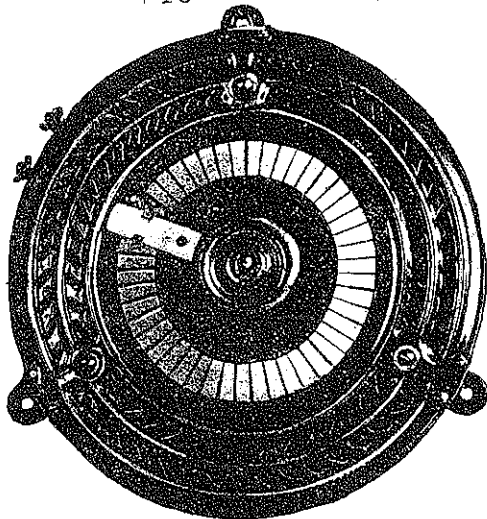


Figure 7

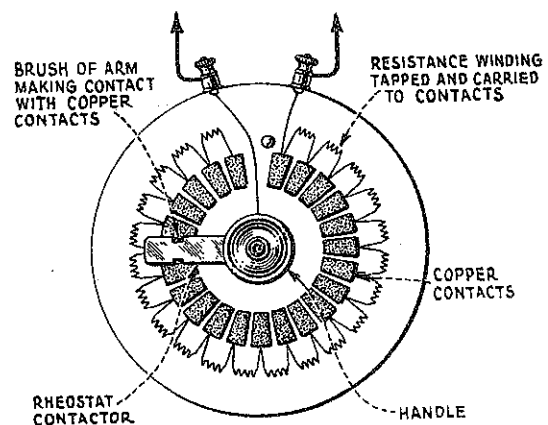


Figure 8

THE FIELD RHEOSTAT

For controlling the field current of a motor or generator the resistance wire must be able to continuously carry the current supplying the field coils. The rheostat field is, consequently, different in design from the starting resistance due to the constant current flow through the field. The starting resistance carries the current only during the

short time required to bring the motor to normal speed. When the starting arm has been forced over to the "ON" position the resistance is cut out and the current then travels directly through the starting arm, as shown in Figures 22 and 23 in the lesson on D.C. motors. The field rheostat, or running resistance as it is sometimes called, is so designed that any part of the resistance may be placed in the circuit and left there. A photograph of the Cutler Hammer type of field rheostat is shown in Figure 7, and a diagram with explanatory notes is shown in Figure 8.

The resistance wire used is an alloy of such metals as it will enhance its resistance properties and which, after it has been placed and connected to the proper contacts, is covered with a specially prepared insulating cement. The entire unit is then placed in an oven and baked. The baked cement presents a hard glazed surface which perfectly insulates the resistance windings and renders them dust and moisture proof. This type of generator field control gives the very close regulation of magnetic field strength which is necessary where the quenched spark type of gap is used in radio transmission.

The motor-generator set requires the same care and attention as the independent motor and generator.

THE ROTARY CONVERTER

Rotary converters have several uses. In commercial practice they are generally used to convert alternating current into direct current for use on traction lines, in the charging of storage batteries, and in electro-plating plants. However, in radio when used on shipboard, the input is direct current and the output is alternating current.

There are no new principles with which you are not familiar in the fundamentals of this machine other than its physical construction. Just remember when you think or hear of a rotary converter that it is simply two machines in one. There is one armature and on this is placed a simple winding which serves to revolve the armature and from which generated current is collected. This generated current is the result of what was, in the independent motor or generator, the counter E.M.F. Furthermore, only one set of field windings is used to supply the magnetic field for both the motor and generator functions of the machine.

Remember that by applying direct current to the windings, alternating current can be obtained by the installation of collector rings placed on the end of the shaft opposite the commutator end or, if it is fitted with a commutator for output current, then direct current can be taken from it. Further, if arrangements are made to revolve the armature by mechanical means then both alternating and direct current will be delivered.

The distinguishing features are as just stated; the use of a single armature for either alternating or direct current. There are only

two bearings needed, and it requires less space for installation. Therefore the construction and installation of the machine as a whole is simplified.

There is the disadvantage however of control of the voltage; full control is not obtained, and this is needed for efficient transmission. Therefore, it is better to use the motor-generator than the rotary converter for radio transmission, even though the cost of the motor-generator is higher.

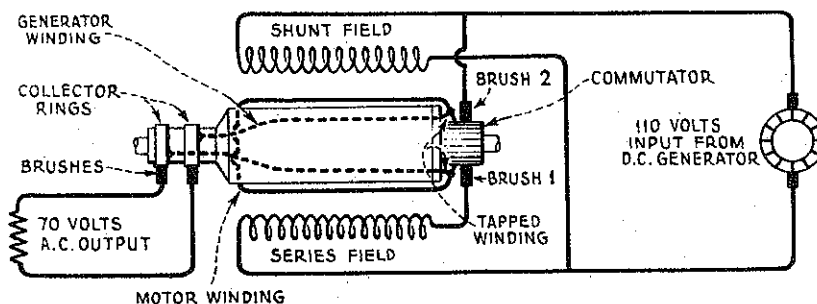


Figure 9

A fundamental circuit of the rotary converter appears in Figure 9. The current flows from the direct current generator through the series field winding into the armature at brush 1, through the armature coils and out at brush 2. The shunt field is connected across the line as in any compound wound machine. As the current is applied to the armature coils rotation results. The dotted lines which are shown connected to the collector rings are taps taken from the armature windings at the point shown.

As the armature revolves in the field, current is developed and is led to the collector rings and delivered to the external circuit as alternating current. The voltage will be maximum when the taps running to the collector rings are connected at the brushes as shown, and minimum when connected to the winding midway between the brushes.

The alternating current value delivered, which is really the counter E.M.F. of the revolving armature, will reach a maximum of approximately 70 volts when 110 volts D.C. is used as the supply. When values of higher voltage are desired a step up transformer must be used on the alternating current side.

THE DYNAMOTOR

The circuit of the dynamotor is shown in Figure 10. The armature carries two separate windings wound in separate slots on the core, one to revolve the armature as a motor and the other for the production of current.

In the figure shown the direct current used to drive the armature is obtained from a 30 volt storage battery outfit. (Commercial machines

can be run on 110 v. D.C. and other voltages.) Voltages ranging from 350 to 2000 volts D.C. may be secured from the generator end, depending upon the design and type of dynamotor. The field is compound wound and is used as both the motor and generator field windings. The speed of this type of machine is 2000 R.P.M. and, to reduce vibration, the entire unit is suspended in a spring suspension saddle shown in Figure 11.

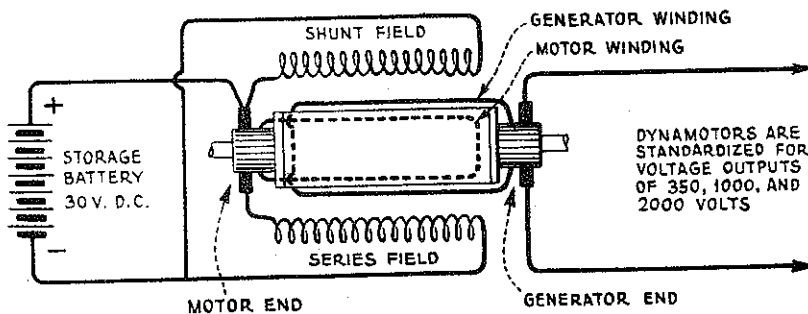


Figure 10

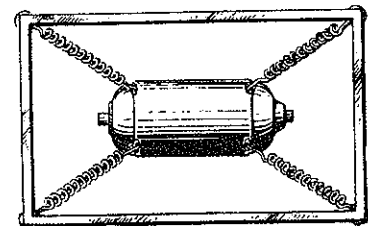


Figure 11

The motor-generator is fast replacing the rotary converter and dynamotor for radio tube work due to the more efficient control realized in both constant speed and constant output in voltage values. The modern tube transmitter calls for a method to supply both low and high voltages. The filament voltage required for the transmitting tube varies from 8 to 16 volts and may be either alternating or direct current. The plate voltage ranges from 350 to 6000 volts.

EXAMINATION - LESSON 12

1. What is a motor-generator?
2. What are the requirements of a motor-generator set?
3. Draw a diagram of a shunt wound motor generator.
4. What are the three types of motor generators?
5. Draw a diagram of a compound wound generator set.
6. How would you regulate the speed of a shunt wound motor-generator?
7. Explain how the voltage output of the generator is controlled in a motor-generator set.
8. What is a dynamotor? Explain fully.
9. What is a rotary converter? Explain fully.
10. What is the difference between a "starting" and "running" resistance?